2023 Urban Fire Forum Position Statement

First-In Responders Providing Neuroprotective ("Heads-Up") CPR as the Standard of Care for Emergency Medical Services Systems

Introduction

Annually, nearly one million individuals experience sudden non-traumatic, out-of-hospital cardiac arrest (OHCA) (1-2) in North America and Europe combined. A significant majority of these patients, exceeding 80%, present with "non-shockable" (NS) electrocardiographic patterns, such as asystole or pulseless electrical activity (PEA) (1-10). Despite the swift response times of our 9-1-1 emergency medical services (EMS) systems, the immediate administration of basic cardiopulmonary resuscitation (CPR), and other well-established advanced life support (ALS) measures, an overwhelming majority do not survive to hospital discharge (1-12).

A small fraction of OHCA patients displaying shockable rhythms may be highly salvageable, but this possibility hinges on specific conditions, notably early and effective CPR performed by bystanders, coupled with rapid defibrillation within minutes (3, 6, 13-14). Nevertheless, when considering all OHCA cases in the United States (U.S.), including those presenting with shockable rhythms, the overall survival rate to hospital discharge was below 10% within the context of progressive EMS systems that monitor outcomes. More notably, the rate of surviving with intact neurological function was below 7.5% (1, 3, 5-10).

In addition to a significant number of unwitnessed events and extended response times, unfavorable outcomes can be attributed to the inherent physiological limitations of traditional CPR. Even in cases of shockable rhythms, early and correctly administered conventional CPR (C-CPR) only manages to deliver approximately 20% of the normal cerebral perfusion pressure (15-21). While chest compressions generate forward-flowing arterial pressure waves, they also generate considerable retrograde venous pressure, resulting in pulsatile increases in intracranial pressure (ICP) with each compression. Consequently, these elevations in intracranial pressure hinder the flow of blood through cerebral arteries (15-21). When combined with the limited refilling of cardiac chambers, C-CPR becomes increasingly ineffective, especially as the duration of untreated cardiac arrest intervals lengthens (15, 16).

Nevertheless, thorough, systematic laboratory research conducted over the past decade, and ongoing clinical investigations, have unveiled novel approaches to alleviate some of the inherent limitations associated with C-CPR. Non-invasive CPR adjuncts, including the combined use of an impedance threshold device (ITD) attached to breathing devices, coupled with suction cup-based active-compression-decompression (ACD), lower intrathoracic pressure during the decompression phase of CPR, both individually and particularly in combination (17-24). By harnessing these complementary mechanisms, ITD/ACD-CPR effectively reduces intracranial pressure, enhances cardiac preload, and improves coronary and cerebral perfusion pressures (15, 17, 19). In clinical trials, the combined approach of ITD-ACD CPR has yielded a remarkable 50% enhancement in one-year survival rates with favorable neurological outcomes compared to C-CPR (24-28).

In more recent developments, the introduction of a gradual head and thorax elevation lasting over 2 minutes (following an initial 2-minute application of ACD-ITD CPR to prime the circulation), has consistently resulted in nearly complete restoration of cerebral perfusion pressures in laboratory experiments. This approach has shown remarkable enhancements in neurologically favorable survival rates, both in cases of shockable and non-shockable OHCA (17, 19, 20-23, 29-34).

Evidence, Analysis, and Rationale for Adopting This Evolving CPR Strategy

The three pivotal adjuncts responsible for achieving these harmonious physiological advantages now include an automated head/thorax-up positioning (AHUP) device (See Appendix). These non-invasive devices, including the ITD, ACD (both manual and automated variants), and AHUP, work in unison to enhance the blood flow generated by conventional CPR. Importantly, they have all received clearance from the U.S. Food and Drug Administration and are presently being introduced into numerous clinical settings throughout the United States (22, 34, 35).

EMS early adopters of the "ITD/ACD/AHUP-CPR" protocol delivered by first responders are already reporting significantly improved patient survival rates when assessing both shockable and non-shockable cases together (22, 38). As in the use of an AED, the more swiftly the ITD/ACD/AHUP-CPR combination is applied, the more favorable the outcome becomes. In general, when administered within 10 minutes after receiving the 9-1-1 call, it is linked to a threefold higher probability of patients experiencing neurologically intact survival, regardless of their electrocardiographic presentation.

However, the most compelling evidence comes from several studies that have demonstrated a remarkable benefit, especially when compared to matched C-CPR controls, in patients who have a non-shockable presentation. For instance, in the case of patients presenting with PEA, the rates of survival with favorable neurological function reach an impressive 10%, a milestone previously unseen. Furthermore, when administered within 15 minutes of receiving the 9-1-1 call (which accounts for 80% of cases), the chances of surviving with intact neurological function for patients with non-shockable rhythms (PEA or asystole) are nearly 14 times higher, even though over 70% of these patients are found with asystole and almost half of non-shockable cases are unwitnessed arrests.

Furthermore, the prospects of achieving neurologically intact survival for patients with unwitnessed arrests who present with asystole (a situation often viewed as futile for resuscitation efforts by most EMS systems) are nearly seven times higher when the ITD/ACD/AHUP-CPR strategy is employed. Although the “rates” of neurologically intact survival for these non-shockable cases predictably remain somewhat low due to the prevalence of unwitnessed arrest scenarios and the associated longer response times, the sheer volume of cases encountered in North America, numbering nearly 1,000 daily, suggests that using this augmented-CPR approach could potentially save tens of thousands of functional lives annually, especially if the time taken to apply ITD/ACD/AHUP-CPR can be consistently expedited.

Among the numerous survivors thus far, one individual, a 50-year-old seasoned EMT, unexpectedly experienced sudden cardiac arrest and underwent an extensive resuscitation effort in St. Johns County, FL, in June 2021. At the time of his cardiac arrest, he had been trained in the retrieval of organs for transplantation, a role that gave him a comprehensive understanding of the various causes of permanent cerebral brain damage. Upon regaining consciousness at the hospital, he discovered the methods employed by the county fire rescue teams to treat him. Astonished by his remarkable recovery, he coined the term "neuroprotective CPR" for this innovative "heads-up" technique. Thus, the term "neuroprotective CPR" (NPCPR) was born from the perspective of a survivor who found himself physically and mentally intact less than 48 hours after his own, albeit lengthy, cardiac arrest. The term NPCPR was swiftly embraced by those utilizing this intracranial pressure-lowering strategy, many of whom had personally witnessed similar successful rescues with positive functional outcomes.

While it is customary in the scientific community to advocate for traditional clinical trials for any new intervention, it is important to note that the "proof of concept" clinical trial involving the foundational devices (ACD-ITD CPR) had already been conducted and demonstrated robust improvements in neuro-intact outcomes. The addition of the heads-up component has clearly amplified this effect. Laboratory studies have consistently shown the normalization of cerebral perfusion pressures and now the achievement of normal end-tidal CO_2 levels in patients undergoing NPCPR offers strong clinical evidence of restored blood flow (in contrast to the mere 15-20% of normal cerebral blood flow achieved through conventional CPR alone).

Furthermore, in the context of OHCA, prominent scientists and biostatisticians have recently endorsed the use of propensity score matching when investigating interventions. This approach is particularly valuable in cardiac arrest studies since all the factors related to outcomes in OHCA are already well-documented. By employing propensity scoring, researchers can optimize their analysis while circumventing the numerous confounding variables and effect modifiers that have impacted OHCA clinical trials. Consequently, propensity-scoring techniques are now being applied to NPCPR studies and these have revealed remarkable distinctions in their outcomes.

Critical Role of the Fire Service in Neuroprotective CPR Delivery

Researchers initially exploring the NPCPR approach in the clinical context started to observe that the timing of the intervention significantly influenced the outcomes. Compared to systems that provided NPCPR equipment through paramedic ambulances only or responding supervisors, generally resulting in some delayed arrival, EMS systems that promptly delivered the equipment through their first responders, typically via fire suppression apparatus crews, achieved notably superior results.

In fact, the best survival rates were consistently seen in fire departments that had designed special backpacks to expedite transport of the NPCPR equipment to the scene and then, when opened, had resuscitation equipment strategically stored/placed in positions that would facilitate a true "pit-crew" approach (APPENDIX). *In turn, their time to application of the NPCPR devices was reduced significantly, and neuro-intact survival rates reflected those innovative approaches developed by the firefighters themselves.*

Moreover, the NPCPR devices are non-invasive tools that can be utilized by any trained rescuer, including firefighters, lifeguards, or other basic life support responders. A forthcoming scientific study set to be published in the esteemed journal, Critical Care Medicine, in the upcoming months, reveals that in more than 40% of cases, only two initial responders were responsible for applying the devices, and in over half of the cases, three or fewer responders were involved (34).

Hence, akin to the widespread use of AEDs, it becomes evident that the majority of NPCPR applications would preferably be administered by firefighters across the nation. Considering the substantial number of cases they encounter, the life-saving potential of NPCPR could rival, if not surpass, the life-saving impact of AEDs. Importantly, NPCPR not only proves more effective when applied early, akin to AEDs, but it also extends its life-saving potential to cases with longer response intervals. In either scenario, the fire service would once again take a leading role in saving lives.

Introducing new equipment to every response vehicle does have budgetary implications, but the costs are not prohibitively high. The expense of the head-elevating device is less than half that of a monitor defibrillator, and it is likely to remain operational for longer periods. Additionally, most departments already carry mechanical suction-cup CPR devices. While the ITD costs approximately $100 per unit used, this expenditure is relatively small compared to the overall resources currently allocated to OHCA response. In any case, even when considering the need to procure all of this equipment, the annualized pro-rated cost over several years remains finite and relatively insignificant when juxtaposed with the annual expenses of operating and staffing response vehicles. Most importantly, the return on investment in terms of improved outcomes is undeniably worthwhile.

Purpose of this Deliverable

All available data consistently point to the fact that, similarly to traditional CPR and AEDs, the more prompt the application of NPCPR, the higher the likelihood of achieving functional survival for the patient. What makes NPCPR exceptional is its potential to save many more patients, regardless of whether they present with shockable or non-shockable rhythms. Considering that the neighborhood fire station is typically the first public safety responder in the United States and other parts of the world, the Urban Fire Forum strongly advocates that all fire departments involved in EMS should adopt NPCPR as a standard operating procedure for managing OHCA.

Several regions in the United States are actively working on strategies to promote the widespread implementation of NPCPR. For instance, a coalition of EMS medical directors across the state of Florida is not only advocating for the routine use of NPCPR but is also in the process of establishing the concept of "Resuscitation Centers" throughout the state.

Therefore, the primary aim of this position statement is to firmly recommend the widespread adoption of NPCPR as a best practice standard of care for all firefighters involved in first response to OHCA cases. It also serves as a preliminary guide on budgeting, training, and implementing this life-saving strategy correctly, emphasizing the importance of avoiding incorrect implementation and ensuring rigorous quality assurance measures.

Adopted Position and Action Items

A Suggested Framework for Implementing Neuroprotective CPR

- The Urban Fire Forum and Metropolitan Fire Chiefs will adopt the definitive position that appropriate use and implementation of Neuroprotective CPR (NPCPR) should become the best practice standard of care for managing out-of-hospital cardiac arrest (OHCA) with the understanding that the fire service generally provides the first-in responders and thus would be most likely to provide the lifesaving effect.
- The Metropolitan Fire Chiefs should align, virtually or in-person, with the Metropolitan EMS Medical Directors Global Alliance (aka medical “Eagles”) to promulgate the critical value of fostering NPCPR in the prehospital setting and advocate for this life-saving patient care in systems yet to adopt such programs. *A large number of the Eagles have become early adopters and have significant experience in proper implementation.*
- The Metropolitan Fire Chiefs will establish advocacy mechanisms, including virtual and in-person conferences, to facilitate networking and mentorship for those wishing to implement NPCPR programs and they will work alongside groups such as the not-for-profit “Take Heart America” initiative (https://takeheartamerica.org/about-us/) which are working on strategies to promulgate NPCPR including funding mechanisms (seed monies from donors, legislative actions, grants and all other avenues of support) to help launch such programs nationwide.
- A manufacturer of one of the three devices used to achieve NPCPR, has a team of train-the-trainer crews who have helped to guide program implementation across the nation, including strategic recommendations for pit crew approaches to expedite ITD/ACD/AHUP-CPR device placement, other patient care interventions including appropriate ventilatory techniques, and how to facilitate accurate data collection and reporting.
- Mentorship and educational programs should be developed to address pragmatic strategies to help overcome barriers such as budgetary considerations and accompanying justifications as well as purchasing considerations, staggered implementation over time, and strategies for optimal roll-out and deployment (along with training resources and receiving hospital staff education/in-servicing and mechanisms to acquire outcome data).
- Fire services using NPCPR should participate in the Heads-Up CPR registry based at Hennepin County Medical Center (Minneapolis, MN). Data collection should match registry requirements.
- It should be emphasized in training and protocols that application of ITDs, ACD-CPR (manual or mechanical), and heads-up/thorax-up elevation are not the lone tasks in terms of managing patients with OHCA; key concomitant actions are establishing airway and respiratory support (as indicated) while providing uninterrupted chest compressions at the right rate and depth and with optimal recoil and minimal interruptions.
- The EMS system should identify hospitals that will optimally manage patients. Several states, such as Arizona and Florida, have designated “Resuscitation Centers” or are in the process of doing so, to ensure optimal management such as early cardiac catheterization or therapeutic hypothermia as indicated.

- It should also be recognized that heads-up/thorax CPR alone could conceivably be detrimental if not implemented correctly or if elevating the head too rapidly without first producing circulatory priming with the ACD-ITD devices to push the blood uphill. Therefore, any elevation of the head and thorax needs to be performed using the ITD/ACD circulatory adjuncts and a patient positioning device that elevates the head and thorax in a controlled and sequential manner.

Some General Roadmaps for Proper Implementation:

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2. Moore JC, Pepe PE, Bachista K, et al: Carry less, do more: properly implementing a basic life support approach to the head-up CPR bundle of care. *EMS World* 2021;50:2-6

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APPENDIX:

Components of Neuroprotective CPR (NPCPR) including the impedance threshold device, a mechanical active-compression/decompression device, and an automated head and thorax elevation device.

Specialized back-pack to facilitate rapid carriage of the equipment to the scene as well as expedite on-scene care in a pit-crew approach with strategic placement of interventions.